US005944893A

United States Patent [19]

Anderson

[11] **Patent Number: 5,944,893**

[45] **Date of Patent: *Aug. 31, 1999**

[54] **METERING DEVICE FOR PAINT FOR DIGITAL PRINTING**

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[*] Notice: This patent is subject to a terminal disclaimer.

[21] Appl. No.: **08/958,292**

[22] Filed: **Oct. 27, 1997**

Related U.S. Application Data

[63] Continuation-in-part of application No. 08/878,650, Jun. 19, 1997.

[51] **Int. Cl.**[6] **B05B 7/00**

[52] **U.S. Cl.** **118/300**; 118/313; 347/21

[58] **Field of Search** 118/62, 63, 64, 118/65, 67, 68, 69, 419, 420, 424, 413, 410, 313, 314, 315, 400; 347/20, 37, 39, 40, 42, 43, 44, 102, 108, 21

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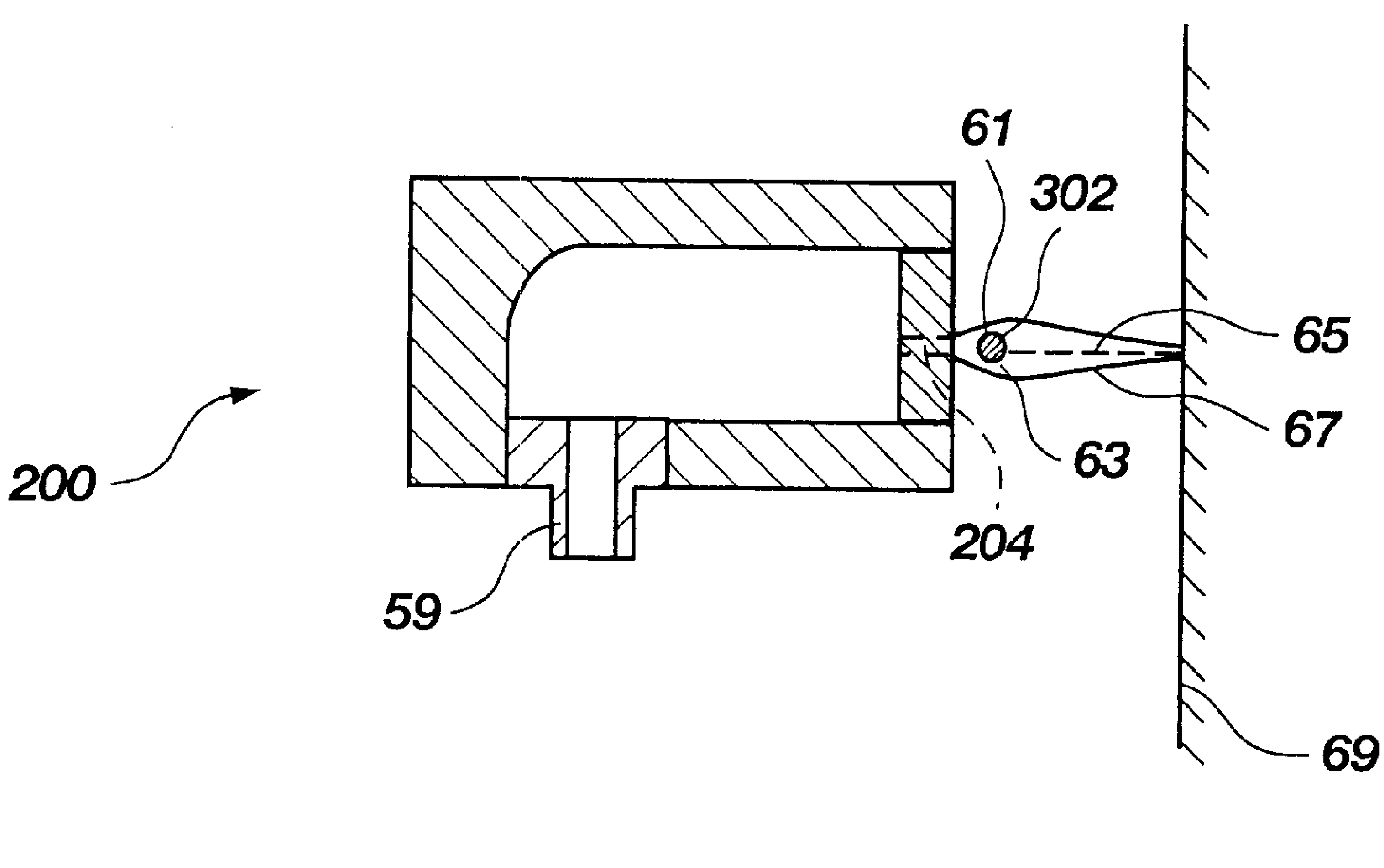
[57] **ABSTRACT**

A paint injector for digital printing in which paint is deposited in metered amounts on a print medium comprising a wheel rotatable by a shaft of a motor, an idler disposed in a paint reservoir, and a segment of wire disposed around the wheel and the idler. The motor is preferably computer controlled such that the rotation of the wheel and thus movement of the wire is selectively controlled. As the wheel is rotated, paint contained within the paint reservoir coats the wire and is thus drawn by the wire in front of an air stream. The air stream pulls the paint from the wire and carries it toward the print medium. By employing a plurality of such paint injectors into a single print head, each containing a different color of paint, and secured to a computer controlled, movable carriage positioned over the print medium, a digital image can be painted by the print head on the print medium.

26 Claims, 7 Drawing Sheets



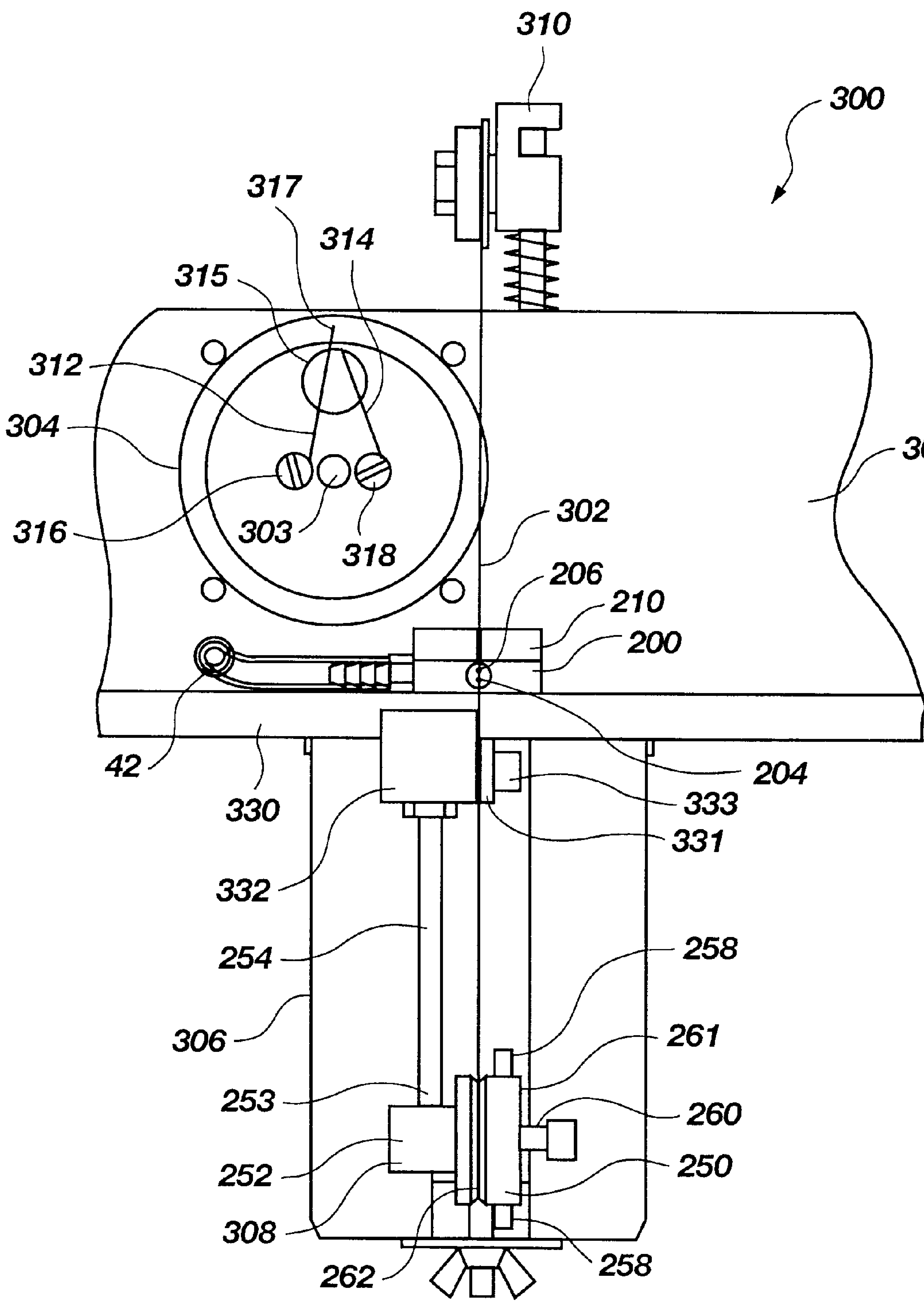

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Fig. 1A

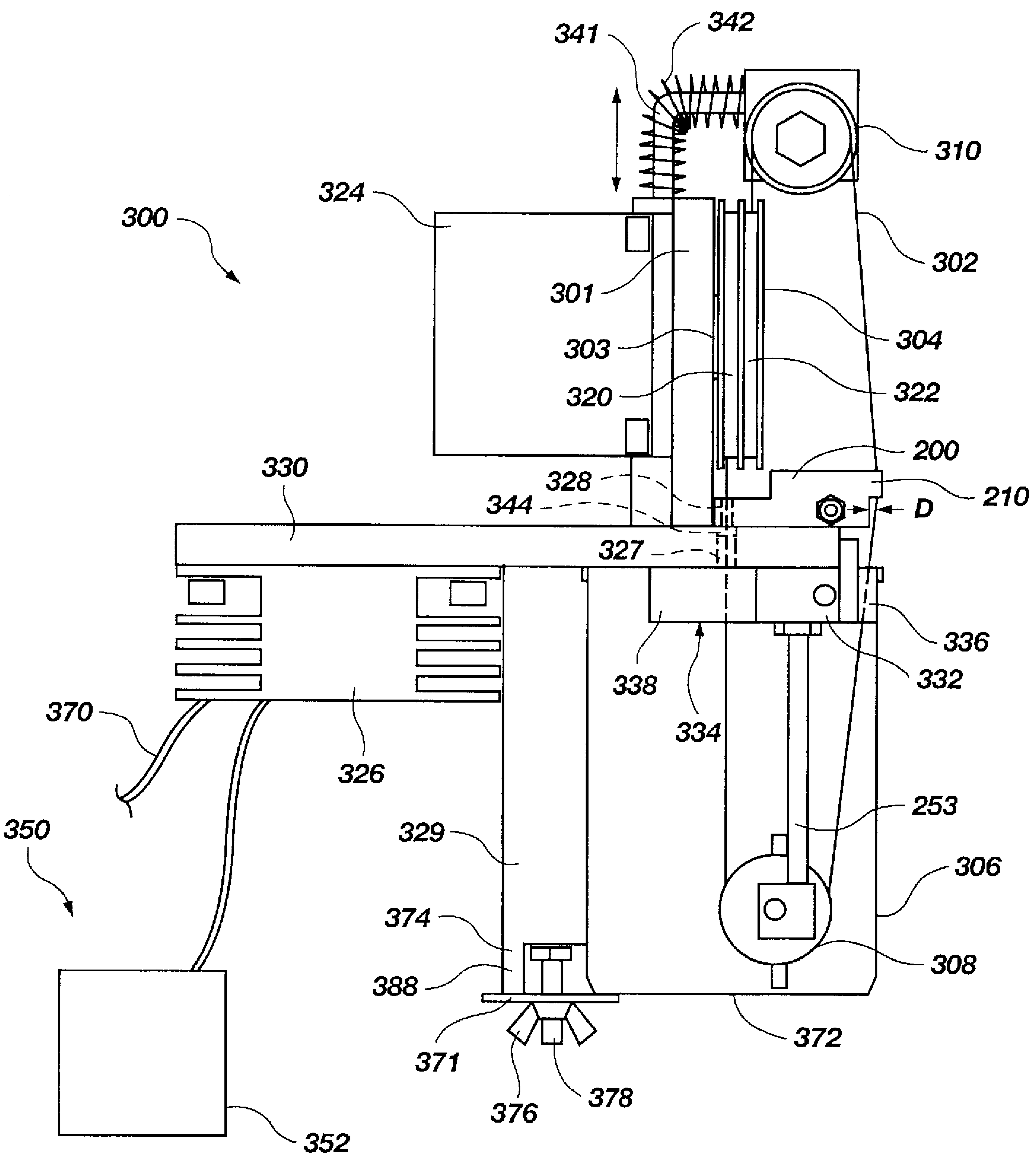
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Fig. 1B

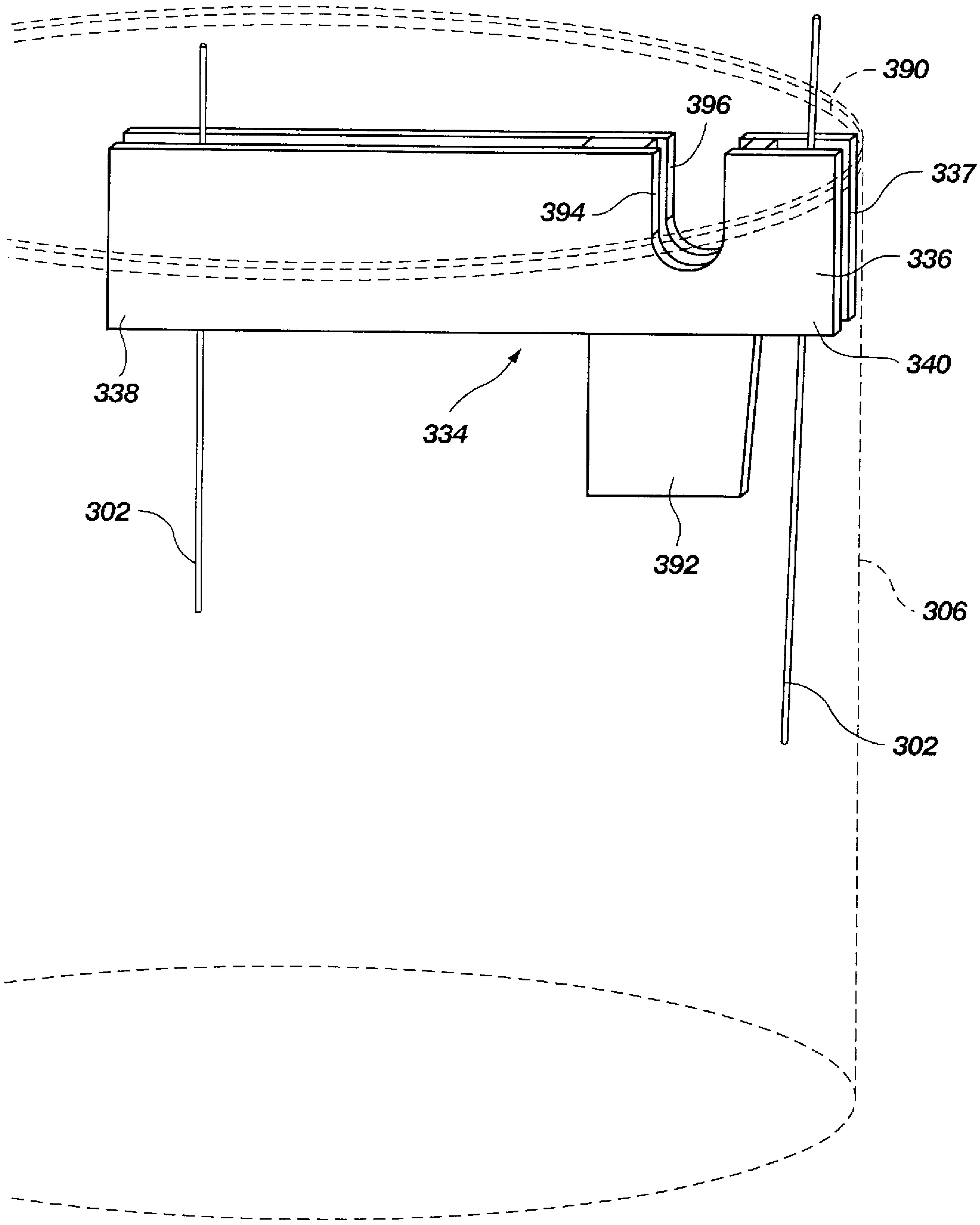


Fig. 2

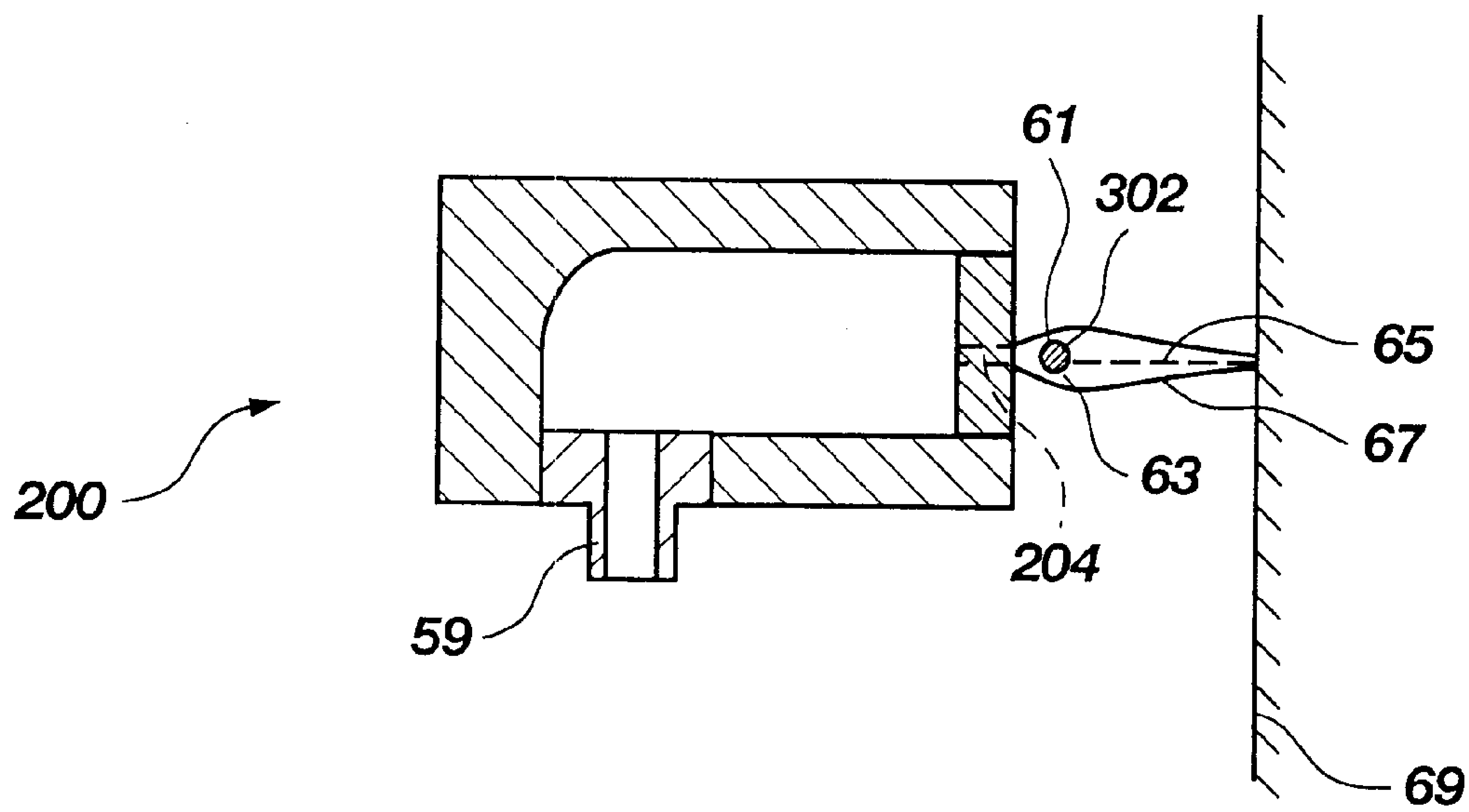


Fig. 3A

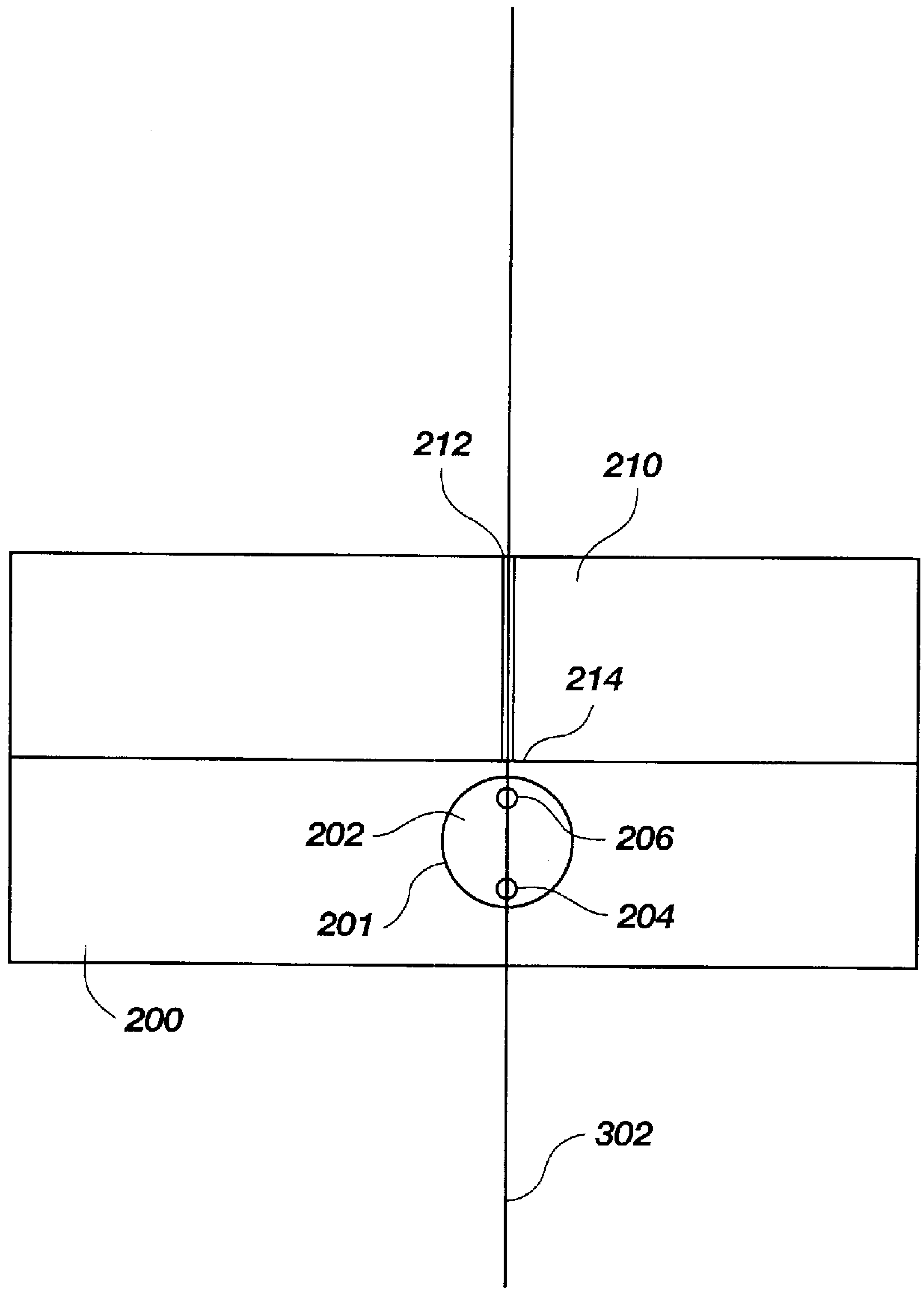


Fig. 3B

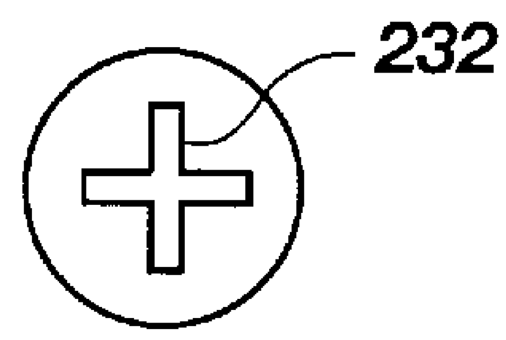


Fig. 3F

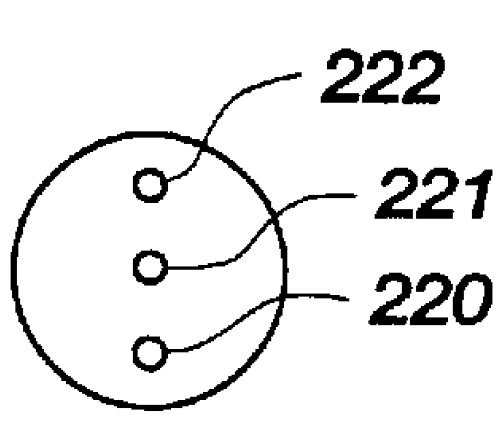


Fig. 3C

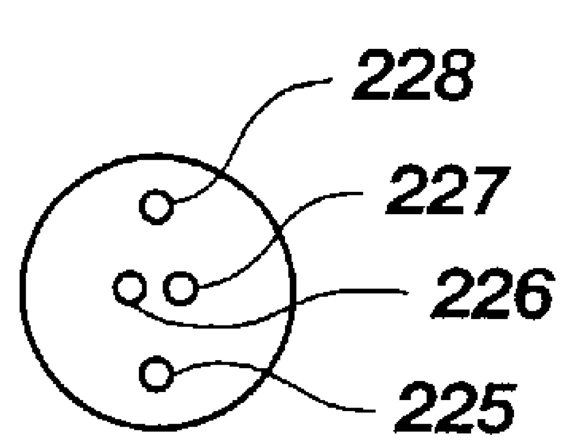


Fig. 3D

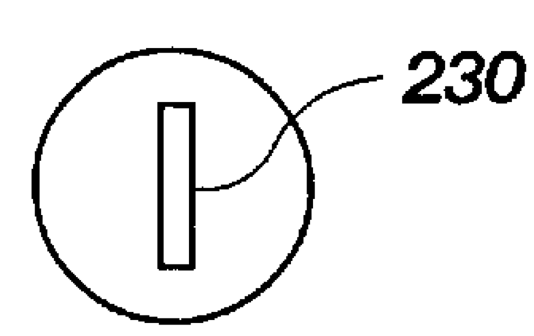


Fig. 3E

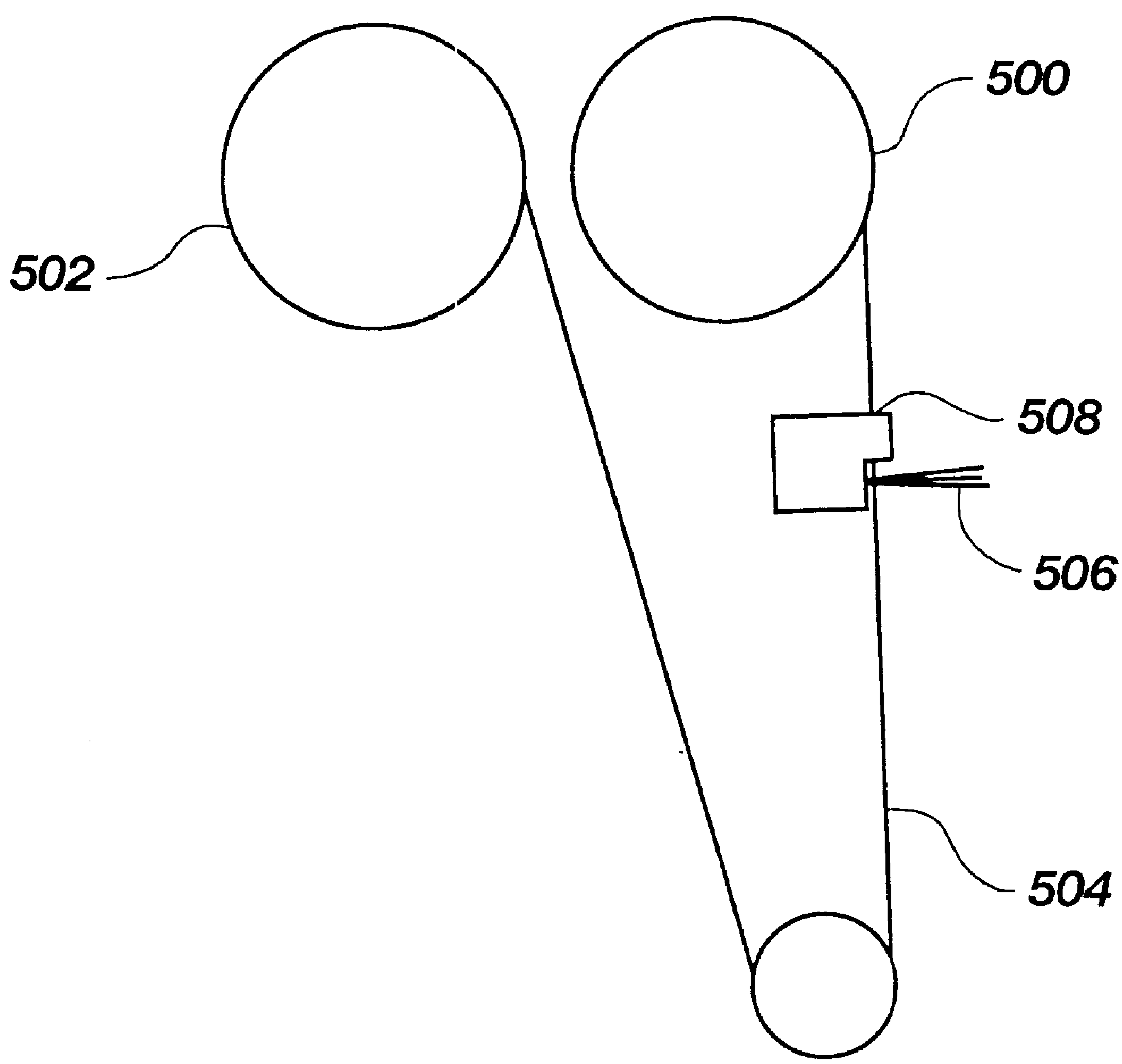
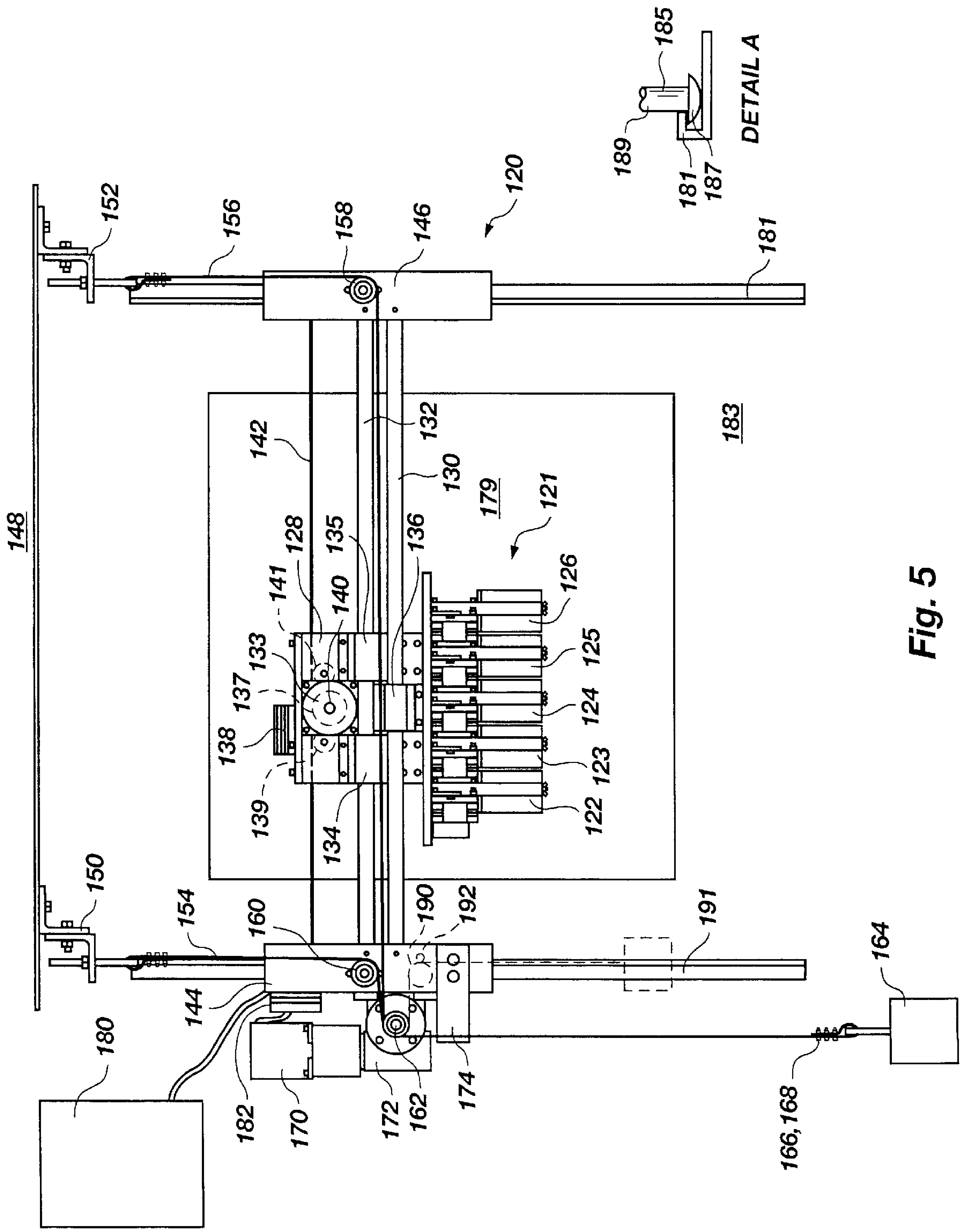


Fig. 4



DETAIL A
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Fig. 5

METERING DEVICE FOR PAINT FOR DIGITAL PRINTING

This application is a continuation-in-part of U.S. patent application Ser. No. 08/878,650, filed Jun. 19, 1997 now pending.

BACKGROUND

1. Field of the Invention

This invention relates generally to an apparatus used for digital painting or printing and, more specifically, to an apparatus that employs a metering device for metering a quantity of paint to be deposited on a surface to be painted or printed and that deposits the metered quantity of paint or other pigmented liquid material on the surface.

2. Background of the Invention

As computer technology has advanced, the ability to view high resolution graphics on a computer monitor or other visual display device has improved, and the capacity to reproduce these high resolution graphics onto a tangible medium has improved in both resolution, quality, and speed. One of the more significant and lucrative color printer technologies to be developed in recent years is the ink jet printer, which mixes several colors, typically cyan, magenta, yellow and black, on the print medium (e.g., paper) to form a color image. Conventional ink jet printing heads include a plurality of nozzles and thermal elements. Ink is expelled from the nozzles in a jet by bubble pressure created by heating the ink with the thermal elements while the nozzles and thermal elements are in close proximity. One such ink jet printing head, as described in U.S. Pat. No. 5,121,143 to Hayamizu, includes a thermal head member having at least one thermal element consisting of a plurality of thermal dot elements and a plurality of electrodes of different widths connected to each thermal element whereby different widths of heated portions of the thermal element are obtainable to vary the amount of ink jetted in one dot. Another such ink jet printing head is described in U.S. Pat. No. 4,731,621 to Hayamizu et al.

Another type of print head is disclosed in U.S. Pat. No. 4,764,780 to Yamamori et al. in which an ink ejection recording apparatus includes a plurality of ink ejection heads connected to an ink tank. Each of the ink ejection heads have an ink nozzle through which minute ink droplets are discharged in accordance with an electric signal. An air nozzle opposing the ink nozzle and adapted for forming an air stream accelerates the ink droplets toward a recording medium.

A conventional airbrush is manufactured by the Paasche Airbrush Co. In Harwood Heights, Ill. The airbrush employs a reciprocating needle that retrieves paint from a reservoir and exposes the paint on the needle to a jet of air. The paint is blown from the needle and onto a print medium. Metering of the paint, however, is manually controlled by pressing a finger lever to allow air to flow through the airbrush.

Typical desk top ink jet printers for home or office use are relatively inexpensive but are usually limited to printing on standard office size sheets of paper, such as 8½x11 or similar standard sizes. Printers that can accommodate larger formats such as poster-sized sheets, however, are currently thousands of dollars to purchase. Printing machines that can print billboard-sized sheets are typically tens of thousands of dollars to purchase.

Some wide format printers are able to accommodate 16 feet or wider substrates, such as films, paper, vinyl, and the like, and can print 300 ft^2 per hour, depending on the resolution of the print. Such machines sometimes employ piezo printhead technology that employs several printheads per color with numerous nozzles per printhead to deposit ink onto the print medium. Another approach is to employ air brush technology in which inks are metered by valves and/or pumps and deposited onto the substrate. The quantity of ink pumped for each color and the position at which it is deposited on the print medium is typically computer controlled. The print medium is typically provided on a roll in which unmarked medium is fed under the print head and printed medium is re-rolled once the ink has had sufficient time to dry. Large format printers using air brush technology typically have a resolution of up to 70 dpi.

In addition to the cost of the machine itself, which employs relatively small orifices, valves and nozzles for depositing the desired quantity and color of ink on the print medium (e.g., paper), very fine grade inks are used in which particle sizes within the inks are kept to a minimum to help keep the orifices, valves, and nozzles of the ink system from becoming clogged. Such inks are expensive and are not very cost effective for painting or printing billboard sized images. Despite the high quality and expense of ink products, clogging of the printhead is still a problem in current printer technologies.

Many large format printers also use water-based inks that may not be suitable for outdoor use. Accordingly, special waterproofing systems and techniques must be employed, such as treating the printing medium with a substance that binds with the ink once deposited to form a waterproof mark or laminating the print with a weatherproof film. These weatherproofing techniques and processes add expense to the cost of each print.

Thus, it would be advantageous to provide a paint injector or print head employed in a digital printer that does not include orifices and/or nozzles through which the ink or paint must flow and, thus, is not limited by paint particle size or large particle contamination and is relatively insensitive to the physical properties of the paint. It would also be advantageous to provide a device that can utilize paints and inks already designed for the sign and art industries and that can be employed to digitally print on large format media.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a paint injector that can print with many forms of liquid printing materials such as paints and inks.

It is another object of the present invention to provide a paint injector that is relatively simple in construction and relatively inexpensive to manufacture.

It is yet another object of the present invention to provide a paint injector in which the liquid printing material is metered through computer control.

It is still another object of the present invention to provide a plurality of paint injectors in a print head, each paint injector containing a different color, and employing the print head to create a digital image on a print medium.

Accordingly, a paint injector is provided comprising an air nozzle that directs one or more jets of air across a moving member, the member having ink, paint, or other similarly pigmented liquid material disposed thereon. The air pulls the paint from the member and directs it onto a print medium, such as paper, vinyl, film, or other print media known in the art. Preferably, the member is an elongated segment of material that is advanced in front of the air jet or jets by at least one wheel around which the segment is at least partially disposed. Thus, as the segment is advanced in front of the air jet or jets, paint thereon is blown off of the segment and onto the print medium.

In a preferred embodiment, a single wire strand is employed to bring ink or paint contained within a reservoir in proximity with an air stream where it is carried to a print medium. A microprocessor or other controlling device controls the wire so that the speed of the wire's advance through the air stream meters the quantity of paint injected into the air stream. As the wire is advanced through the reservoir, a coating of paint clings to the wire, the thickness of the coating being controlled to a degree by the viscosity of the paint. In addition, a mechanical metering device, such as a scraper riding proximate to or in contact with the wire as it is advanced, may be employed to control the thickness or amount of paint on the wire before it enters the air stream. The wire, having a coating of paint thereon, is then drawn into close proximity to one or more jets of air. As the paint on the wire reaches the jet or jets of air, it is pulled or blown from the wire and into the air stream until it impacts the print medium. In order to keep the wire positioned in front of the air stream, a wire guide may be employed proximate to the air nozzle to prevent the wire from being forced away from the air stream and to reduce vibration of the wire in the air stream.

The wire is preferably drawn through the paint reservoir and thus coated with paint by being disposed at least partially around a pulley or wheel driven by a motor and at least partially around a rotatable or stationary idler or guide that is at least partially immersed in paint or other pigmented liquid material. A processor, controller, microprocessor, processor, or other computing device, controls the advance of the motor and thus movement of the wire. In addition, the processor controls movement of the paint injector or injectors as it is swept across a print medium. By utilizing a plurality of paint injectors in a print head, each containing a different color of paint, and by controlling and coordinating the metering of the paint and the position of the print head, as with error diffusion, stochastic screening, or blue noise algorithms as known in the art, a digital image can be created on the print medium.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1A** is a front view of a first preferred embodiment of a paint injector in accordance with the present invention;

FIG. **1B** is a side view of the paint injector illustrated in FIG. 1A;

FIG. **2** is a perspective side view of a scraping device in accordance with the present invention;

FIG. **3A** is a cross-sectional top view of a nozzle body in accordance with the present invention;

FIGS. **3B–3F** are front views of five preferred embodiments of nozzle orifice configurations in accordance with the present invention;

FIG. **4** is a schematic side view of a second embodiment of a paint injector in accordance with the present invention; and

FIG. **5** is a back view of a printing device employing a print head having a plurality of paint injectors in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE PRESENT INVENTION

FIG. **1A** illustrates a preferred embodiment of an single color paint injector, generally indicated at **300**, in accordance with the present invention for selectively and controllably depositing paint, ink, dye, or other liquified pigmented material onto a print medium. The paint injector **300** is preferably attached to a frame or plate **301** shown in partial view to which a plurality of such paint injectors may be secured. The paint injector **300** comprises a segment of material such as a single strand of wire **302** (e.g., steel music wire, stainless steel, spring metal, nickel/titanium alloy, and/or other metals and alloys or of such materials as kevlar, graphite, nylon or other materials that are flexible and have a substantially high tensile strength), a wire hoop or loop as made from an endless cable or formed by photo etching techniques from flat sheet/shim stock, a band, a ribbon, or a relatively thin structure having material windable from a freely rotatable idler, spool or wheel onto a drive spool or wheel, or any other structure upon which liquified pigmented material could be applied. The wire **302** is drawn in front of a nozzle body **200**, and more specifically, in the path of an air stream emanating from a pair of nozzle orifices **204** and **206** defined in the nozzle body **200**.

An air supply hose **42** is secured to the nozzle body **200** and supplies air through the nozzle orifices **204** and **206**. The nozzle orifices **204** and **206** are aimed at a segment of the wire **302** passing thereby. A wire guide **210** defining a longitudinal slot **212** is positioned proximate the nozzle orifice **204**. The wire **302** rides within the slot **212** and is thus held in relative position to the nozzle orifices **204** and **206** so that air passing therethrough does not substantially move the wire **302** from in front of the nozzle orifices **204** and **206** or cause the wire **302** to substantially vibrate.

In this embodiment, the wire **302** is both advanced by and taken up by a single wheel **304**. The wire **302** is fed from the wheel **304** into a container or paint reservoir **306**, at least partially around a rotatable or stationary idler or guide **308**, through the wire guide **210**, at least partially around a rotatable or stationary wire biasing idler or guide **310**, and rewound upon the wheel **304**. The guide **308** is comprised of a substantially cylindrical wheel **250** rotatably attached to a base **252**. The wheel **250** is rotatable upon the axil **260**, in this embodiment formed from a #10–32 socket head screw comprised of teflon/delrin. Likewise, the guide **308** may comprise a non-cylindrical, non-rotatable member having a groove or slot therein in which the elongate segment of material, in this embodiment a wire **302**, can slide upon rotation of the wheel **304**. A plurality of projections or paddles **258** are attached to or formed integral with a shaft **260** attached to the wheel **250**. These paddles **258** mix the paint contained in the reservoir **306** as the wheel **250** rotates by movement of the wire **302** through the circumferential groove **262**. Those skilled in the art will appreciate that the paddles **258** may comprise fins or other protuberances or may be configured as slots or grooves in the surface **261** of the wheel **250** in order to create an irregular surface.

The guide **308** is maintained in position within the reservoir **306** by an elongate member **254** depending from a frame or plate **330**. The elongate member **254** is secured to the plate **330** through a scraper attachment member **332**. The guide **308** is secured to a distal end **253** of the elongate member **254**.

The wire **302** is secured to the wheel **304** at both ends **312** and **314** as with threaded fasteners **316** and **318**, respectively, or other means known in the art. The wire **302** passes through a larger aperture **315** to the other side of the wheel **304** and is wound onto the wheel **304** from the feed end **314** of the wire **302**, around the various components of the injector **300**, through a smaller aperture **317**, and secured back to the wheel **304** at the take-up end **312**. Preferably the wire **302** is comprised of a single strand having a diameter of approximately 0.005 to 0.006 inches in diameter, although wires of other dimensions may work equally as well, and is of a length that can be wrapped around the wheel **304** several times.

As better seen in FIG. **1**B, which shows a side view of the paint injector **300** of FIG. **1**A, the wheel **304** defines two circumferential grooves **320** and **322**. The first circumferential groove **320** defines the feed side of the wheel **304** while the groove **322** defines the take-up side. An electronically controllable drive mechanism, such as a motor **324**, is employed to rotate the wheel **304** and thus advance the wire **302**. The motor **324** may be a stepper motor, a DC motor, or other device known in the art in which rotational advancement of the wheel **304** can be selectively and/or incrementally controlled. The motor **324** is preferably electronically connected to and controlled by a processor or controller, generally indicated at **350**, comprising an electronics module **326** and a signal generating device **352**, such as a personal computer employing a microprocessor or other devices that can generate discrete signals to instruct selective rotation of the shaft **303** of the motor **324**. The circuitry of the electronics module **326** receives one or more signals from the device **352** and rotates the shaft **303** of the motor according the signal(s). Those skilled in the art will recognize that such circuitry could be incorporated into the device **352** or that the components of the device **352** could be incorporated into the module **326**. In the case where the motor **324** is a stepper motor, the signal(s) is sent in the form of one or more electrical pulses, each pulse designating a single step or a certain number of steps that the shaft **303** of the stepper motor **324** is to be rotated. A typical stepper motor provides **200** steps per revolution with each step being activated by a voltage in the range of 0.2 to 5 volts, depending on the voltage requirement of the motor. Thus, if it is desired to deposit the quantity of paint drawn by the wire **302** in one half of a revolution of the wheel **304**, 100 pulses would be sent by the device **352**, the module **326** would convert each pulse into a voltage depending on the voltage requirement of the stepper motor **304** sufficient to cause the stepper motor **324** to rotate its shaft **303** one step, and the shaft **303** would rotate 100 steps. A power supply line **370** may be connected to the module **326** to provide the requisite voltage to turn the shaft **303** of the motor **324**. A preferred way of driving the motor **324** is to perform all shaft **303** advances for the paint injector **300** by time calculations made by the device **352** thereby eliminating the need for a calculating device within the paint injector **300** itself. Such time calculations may employ error diffusion, stochastic screening, or blue noise algorithms as are known in the art. Thus, all wire **302** advances for the same color of paint, in addition to spatial motions of the paint injector **300** relative to the print medium for depositing the metered paint at relatively precise locations, can be made by the device **352** driving logic lines connected to the module **326** driving the motor **324**. If a DC servo motor is employed, the signal sent from the device **352** would be converted into a voltage by the module **326** necessary to rotate the shaft **303** of the DC motor a desired portion of a rotation, and a feedback device, such as an optical encoder, would be employed by the module **326** to control the precise rotation. It is also contemplated that a crude metering of paint could be accomplished by simply providing a timed duration of power to a motor without feedback.

When the motor **324** is activated to advance the wire **302** by electronics **326**, the wire passes through a first bore or slit **328** extending through the nozzle body **200**, through a second bore **327** defined in and extending through a frame or plate **330**. The plate **330** is employed to support the electronics **326**, elongated support member **329** that supports the reservoir **306**, and a scraper attachment member **332**. The reservoir is maintained in position relative to the elongated support member **329** by a small plate **371** abutting the bottom surface **372** of the reservoir **306**. The small plate **371** is secured to the distal end **374** of the elongated support member **329** with an internally threaded fastener **376** which is threaded onto an externally threaded shaft **378** secured to the distal end **374** of the elongated support member **329**. In addition, the elongated support member **329** includes a flange **388** depending from the distal end **374** such that the fastener **376** biases the small plate **371** against the surface **374** of the reservoir **306**. Other configurations of reservoirs and containers and means of attaching such containers relative to the plate **330** are also contemplated without departing from the spirit of the present invention. In addition, it is also contemplated that a reservoir may not be required if the pigmented material being deposited is dribbled or otherwise applied, as by wiping across a paint soaked pad, to the wire **302**. A scraper attachment member **332** provides both a foundation for attachment of the elongated support member **253**, to which the idler or guide **308** is attached, and a scraper device **334** comprised of a pair of elongated plates, only one **336** of which is visible.

As better shown in FIG. **2**, the elongate plates **336** and **337** are maintained in substantially parallel relationship proximate to the top edge **390** of the reservoir **306**, represented by dashed lines. The plates **336** and **337** are each provided with a slot **394** and **396** for securement to the scraper attachment member **332** illustrated in FIGS. **1**A and **1**B. As shown in FIGS. **1**A and **1**B, the scraper attachment member **332** is preferably comprised of a block attached to the plate **330**. The plates **336** and **337** are secured to the block **332** by a small plate **331**, which spreads the clamping force across the plates **336** and **337** and a screw **333**, such as a 10–32 socket head screw, which passes through the slots **394** and **396** securing the plates **331**, **336**, and **337** to the block **332**. Preferably the plates **336** and **337** are comprised of metal, such as spring steel, having a thickness of approximately 0.013 inches. The wire **302** passes between the plates **336** and **337** of the scraper device **334** proximate a first end **338**, is fed around the idler or guide **308** (see FIG. **1**B) and through the scraper device **334** a second time proximate a second end **340** thereof. The passage of the wire **302** through the scraper device **334** at the second end **340** wipes a substantial amount of paint from the wire **302** and provides a uniform coating of paint on the wire **302**. The thickness of the paint remaining on the wire **302** may be adjusted by providing a spacer **392** between the plates **336** and **337** of the scraper device **334**. For example, the spacer **392** could be provided having a thickness of 0.006 inches at the clamped point between the plates **336** and **337** to accommodate a wire **302** having a diameter of **0.006** inches in order to limit wear of the wire **302** but substantially control the amount of paint retained by the wire **302** after passage through the scraper **334**. The paint wiped from the wire **302** by the scraper device **334** will accumulate on the scraper device **334** and drip back into the reservoir **306**. The remaining paint will be removed from the wire **302** by the air jets passing through the nozzle orifices.

Referring again to FIG. **1**B, the wire **302** passes in front of the nozzle body **200** and is held relative thereto by the wire guide **210**. As illustrated, the wire guide **210** holds the wire a desired distance D, such as about 0.040 inches, from the nozzle body **200** and thus the nozzle orifices (not visible). In addition, the wire guide **210**, in conjunction with the biased wire guide **310** keeps tension on the wire **302** in front of the nozzle orifices by imparting a bend to the wire at the wire guide **210** and thus holds the wire in relative position to the nozzle orifices.

By providing a rotatable wire biasing guide **310**, wire tension on both sides of the biasing guide **310** may be maintained on the wire **302** as the wire **302** is unwound and rewound onto the wheel **304**. This may prevent the wire **302** from pulling down unequally on the spring **342** and the wire from jumping out of the biasing guide **310**. The biasing guide **310** is important because the length of the wire **302** extending between the groove **320** and the groove **322** will vary as the wire **302** is wound and unwound between the two grooves **320** and **322**. The guide **310** is secured to an elongated guide support member **341** formed into a ninety-degree elbow configuration. As such, the guide **310** is positioned to feed the wire **302** to near the center of the groove **322**. Of course, the guide **310** may be positioned at other points along the path of the wire **302** in order to maintain tension on the wire **302**. The support member **341** is secured to the frame or plate **301** in a manner that allows the support member **341** to move (e.g., slide) in directions indicated by the arrow. A biasing device **342**, such as a coil spring positioned around the support member **341**, is employed to bias the guide **310** away from the wheel **304**. Accordingly, depending on the spring force of the biasing device **342**, a desired tension can be maintained in the wire **302** during operation of the injector **300**. Those skilled in the art will understand that other biasing devices or members and support structures may be employed to maintain tension in the wire **302** during the course of operation of the device.

Of course, only a limited amount of wire **302** can necessarily be wound onto the wheel **304**. While it may be possible to provide enough wire **302** that one pass of the wire from the groove **320** to the groove **322** is sufficient to complete an entire printing application, it is more likely the case, especially for a print job of any substantial extent, that the wire **302** will be required to be rewound into the groove **320** during the course of printing. It is preferred that the wire **302** be rewound after each pass of the injector **300** over the print medium. In a rewind cycle, the scraper device **334** provides secondary wiping of the wire **302** as it passes through the scraper device **334** and onto the wheel **304** in groove **320**. It is noted that while the scraper device **334** which provides both wiping of the wire **302** when the wire is being advanced and wiping of the wire **302** when it is being rewound could be comprised of two separate scraping devices. The secondary wiping of the wire is obviously important because the wire **302** is recoated with paint as it is drawn through the paint reservoir **306**. The bore **328** provides a wire guide to align the wire **302** with the groove **320**. In addition, it is preferable that the bore **328** be of a smaller size than the bore **327** such that a wiping device **344** be provided around the wire **302** in the bore **327**. Preferably the wiping device **344** is comprised of a string of material, such as dental floss, tied in a knot around the wire **302** that is of a size that it cannot pass through the bore **328** or through the scraper device **334**. Preferably, such a knot is formed by wrapping the string of material three or four times around the wire **302** and tying the ends tightly together. Of course, those skilled in the art will recognize that other wiping devices could be employed, such as sponges and other fabrics and materials that can substantially wipe any remaining paint from the wire **302**. The wiper device **344** substantially removes the remaining paint from the wire **302** as it is rewound into the groove **320** in order to keep groove **320** substantially free of paint.

As shown in FIG. **1A**, in operation, paint or other pigmented liquid material contained in the container **306** is picked up by the wire **302** and advanced by rotation of the wheel **304**, indicated by the arrow, in front of the nozzle orifices **204** and **206**. In order to help control the speed of rotation of the wheel **304**, a series of gears, wheels, belts, or combinations thereof may be employed between the shaft **303** of the motor (see FIG. **1B**) and the wheel **304**. Air being blown through the nozzle orifices **204** and **206** disperses or pulls paint from the wire **302** toward the painting surface. Depending on the viscosity of the paint, the cross-sectional diameter of the wire **302**, the use of a mechanical scraping device, and the diameter of the wheel **304** formed by the groove in which the wire **302** resides, a relatively precise amount of paint can be effectively metered by relatively precisely rotating the shaft **303**. Such an apparatus may produce images having a resolution of approximately 100 dpi or better, which is more than adequate for larger format prints such as poster-size, billboard-size, and the like. The force of the air stream upon the wire **302** removes the remaining quantity of paint on the wire **302** in such a manner as to produce a relatively clean wire **302** for engagement with the wheel **304**. Thus, the wire **302** can be wound upon the wheel **302** without the wheel **304** becoming filled or otherwise obstructed with paint. While an air stream has been described as the preferred vehicle for transporting the paint from the wire **302** to a print medium, it is also contemplated that other fluid streams, such as thinner or other materials known in the art, may be employed or mixed with air or another gas to transport the paint from the wire **302** to a print medium.

The nozzle body **200** is shown in cross-section in FIG. **3A** and includes an air supply connector **59** and two orifices **204** and **206**, only one of which is visible, that produce low pressure zones **61** and **63** on both sides of the wire **302** and thus draw the paint **65** from the wire **302** into the air stream **67**. The low pressure zones **61** and **63** also help keep the wire **302** centrally located in front of the nozzle orifices **204** and **206** by providing substantially equal pressure on both sides of the wire **302**. Preferably, the orifices **204** and **206** each have a diameter of approximately 0.014 inches and a length of 0.050 inches. While a two nozzle configuration has been illustrated, various other nozzle configurations may be equally effective for removing the paint **65** from the wire **302** while reducing spray or divergence of the paint within the air stream **67** and are thus contemplated within the scope of the present invention.

Spatter created by the paint **65** impacting the print medium **69** and by turbulent flow of air around the wire **302** may be controlled by controlling the pressure of air supplied to the orifices **204** and **206**, and thus the velocity of the air stream **67**. For orifices **204** and **206** as described, an air pressure of approximately 10 psi would be sufficient to direct the paint **65** toward the print medium **69** and substantially clean the wire **302** while minimizing spatter. Higher pressures of 80 psi or more may have equal utility depending on the distance of the wire **302** from the print medium **69**, the quantity of paint **65** on the wire **302**, and the diameter of the orifices **204** and **206**.

FIG. **3B** illustrates a front view of the nozzle body **200** which has a substantially cylindrical nozzle insert **202** secured within an opening **201** thereof. The nozzle insert **202** defines the two orifices **204** and **206** therein oriented in substantial alignment with the wire **302**. Of course, the two orifices **204** and **206** may be integrally formed with the nozzle body **200**. A wire guide **210** is secured to or integrally formed with the nozzle body **200** and defines an elongated slot **212** therein having a length sufficient to guide and stabilize the wire **302** in front of the nozzle orifices **204** and **206**. As paint or other pigmented liquid material is drawn in front of the nozzle insert **202**, air flowing through the first nozzle orifice **204** removes a substantial amount of paint or pigmented liquid material that has been applied to the wire **302** and disperses the paint onto a print medium. The second nozzle orifice **206** removes substantially all of the remaining paint or pigmented liquid material from the wire **302**. Utilizing such a nozzle orifice configuration has been discovered to be important in reducing the amount of splatter that can occur after some period of painting. Paint that would otherwise remain on the wire **208** after passing through the air stream of the nozzle orifice **204** or that is blown upwardly onto the wire guide **210**, may accumulate on the lower edge **214** of the wire guide **210**. If a sufficient amount of paint or pigmented liquid material is present on the lower edge **214** to form a droplet, the droplet will eventually fall into or be drawn into the air stream depositing a splatter of paint onto the print medium. By providing the second nozzle orifice **206** to remove any remaining paint from the wire **208** and to capture paint directed in an upward direction from the first nozzle orifice **204** that may otherwise be deposited on the wire guide **210**, an accumulation of paint does not occur on the lower edge **214** and splattering is substantially reduced and/or prevented, increasing the quality and resolution of the print. Of course more nozzle orifices could be provided, such as three orifices **220**, **221**, and **222** as illustrated in FIG. **3**C, four orifices **225**, **226**, **227**, and **228** as depicted in FIG. **3**D to provide efficient paint removal and stabilization of the wire, a single elongated slot orifice **230** as shown in FIG. **3**E, or a single cross-shaped orifice **232** as illustrated in FIG. **3**F.

While, as previously discussed, a single wheel may be employed to advance and take-up the wire, as schematically illustrated in FIG. **4**, it is equally plausible that two wheels **500** and **502** may be employed to advance the wire **504** in front of an air stream **506** emanating from a nozzle body **508**. Accordingly, the wheel **500** could advance the wire **504** during the printing sequence and the wheel **502** could rewind the wire at the end of each printing cycle.

Referring now to FIG. **5**, a digital printing device **120** employing a plurality of paint injectors, in this example five (5) paint injectors **122**, **123**, **124**, **125**, and **126**, such as the paint injectors herein described, is attached to a moveable carriage **128**. Each paint injector **122**, **123**, **124**, **125**, and **126** contains a different color of paint comprising a multi-color print head **121**. Of course, more or less paint injectors may be employed depending on the needs of the user. For example, paint injector **122** may contain yellow, paint injector **123** may contain magenta, paint injector **124** may contain cyan, paint injector **125** may contain black, and paint injector **126** may contain white. Because the print medium is typically white, white paint is not used as a standard color in conventional printheads. Standard process colors include yellow, magenta, cyan, and black. Having white paint added to the mix of colors, however, allows a graphics artist to manually add detail to a wet print without "mudding" the colors or the image. It is also contemplated that more or fewer paint injectors may be included with various colors contained therein depending on the desired colors of print to be produced.

To selectively move the carriage **128** in an x-direction, the carriage **128** is mounted on a pair of shafts **130** and **132**, preferably 1 inch round shafts, with linear bearings **134**, **135**, and **136** that allow the carriage **128** to relatively easily slide along the shafts **130** and **132**. A motor **133**, such as a stepper motor, controlled by x-drive electronics **138** and having a sprocket **137** attached to the shaft **140** thereof is employed to move the carriage **128** along the shafts **130** and **132**. The sprocket **137**, in conjunction with freely rotatable sprockets or idlers **139** and **141**, engages with the drive chain **142** (shown in dashed lines) to move the carriage **128** along the shafts **130** and **132**. The drive chain **142** as well as the shafts **130** and **132** are fixed between a left support assembly **144** and a right support assembly **146**. It is also contemplated that the motor **133** be mounted on either the left assembly **144** or right assembly **146** or some other structure to lower the mass of the carriage **128**. Such a motor would then drive a moveable chain or belt to position the carriage **128** at the desired location.

To selectively move the carriage **128** in a z-direction, the entire printing device **120** is mounted to an overhead structure such as a ceiling **148** with bracket assemblies **150** and **152**. The left bracket assembly **150** supports a pair of left z-drive roller chains **154** (only the closest of which is visible) and the right bracket assembly **152** supports a pair of right z-drive roller chains **156** (only the closest of which is visible). A freely rotatable sprocket **158** is mounted to the right assembly **146** and engages one of the right z-drive roller chains **156**. Similarly, on the opposite side of the right assembly **146**, another freely rotatable sprocket mounted to the right assembly **146** engages the other of the z-drive roller chains **156**. Likewise, a freely rotatable sprocket **160** is mounted to the left assembly **144** and engages one of the left z-drive roller chains **154** and another freely rotatable sprocket on the opposite side of the left assembly **144** engages the other of the left z-drive roller chains **154**. Both the left z-drive roller chains **154** and the right z-drive roller chains **156** engage with z-drive sprockets **162** (four in all, only the closest of which is visible) and have weights **164**, (four in all, only the closest of which is visible) suspended from their distal ends **166** and **168**, respectively, to keep the chains **154** and **156** taut around the sprockets **162**. Similar to the x-drive assembly, the sprockets **162** are driven by a motor **170**, such as a stepper motor, that engages with a worm gear unit **172** as is known in the art to transfer rotational movement of the motor **170** to the sprockets **162** and thus move the left and right assemblies **144** and **146** and thus the carriage **128** in a z-direction. Chain guards, such as chain guard **174**, may be utilized near the sprockets **162** to maintain engagement of the chains **154** and **156** with the sprockets **162**. Likewise, as illustrated by dashed lines, other freely rotatable sprockets **190** may be employed to direct the chains **154** and **156** around a larger portion of the sprockets **162** and thus prevent the chains **154** and **156** from skipping or falling from the sprockets **162**. A retaining rod **192** may also be employed to help maintain the chains **154** and **156** in engaging contact with the freely rotatable sprockets **190**.

In order to keep the print head **121** from swaying either away from a print medium **179** or from side to side, a track **181** may be vertically oriented and secured to the structure **183**, such as a wall or frame, to which the print medium **179** is temporarily secured. As shown in DETAIL A, the track **181** has a J-shaped cross-section into which a guide member **185** can engage and slide therethrough. In this preferred embodiment, the guide member **185** is comprised of a threaded bolt having its head **187** retained by the track **181** and its shaft **189** secured to the right assembly **146**. Accordingly, movement of the right assembly **146** is restricted from moving away from the print medium **179** or toward the left assembly **144**. Similarly, a second track **191**, having an opposite orientation to the track **181**, is secured to the structure **183** to restrict movement of the left assembly

144 from moving away from the print medium **179** or toward the right assembly **146**. Those skilled in the art will recognize that other track and guide member assemblies could be employed to maintain the printing device **120** in position relative to the print medium **179**, such as a single C-shaped track and retaining member arrangement.

In operation, the print medium **179** is positioned in front of the digital painting device **120** and a controller **180**, such as a computer, sends signals to the painting device **120** to direct movement of the print head **121** and dispersion of paint from the paint injectors **122**, **123**, **124**, **125**, and **126** to form an image on the print medium **179**. More specifically, signals from the controller **180** are sent to the z-drive electronics **182** which in turn convert the signals into movement of the sprocket **162** along the chains **154** and **156** corresponding to the desired z-direction position of the print head **121**. Likewise, signals from the controller **180** are sent to the x-drive electronics **138** corresponding to the desired x-direction position of the print head **121** along the shafts **130** and **132**. The controller **180** also individually controls each of the paint injectors **122**, **123**, **124**, **125**, and **126** to deposit the desired color of paint on the print medium **179** at the desired location. Thus, the printable image size of the printing device **120** is only limited by the length of the chains **154**, **156**, and **142** and the length of the shafts **130** and **132**.

The present invention also contemplates that the print head **121**, or individual paint injectors **122**, **123**, **124**, **125**, and **126** could be employed with other digital printing devices known in the art for digital painting purposes. For example, the print head **121** could be employed in a device where movement of the print head is along an x-axis while a roll of print medium, such as vinyl, is selectively advanced relative to the print head **121** to affect movement along the y- or z-axis. With such a device, the size of print medium may only be limited by the size of the roll of print medium. Likewise, a rigid frame to which the print head, according to the present invention, can be mounted and upon which the print head could be selectively moved could also be employed to allow z- and x-direction movement or x- and y-direction movement of the print head, depending on the orientation of the frame.

It is also contemplated that a digital printer, such as the digital painting device **120** illustrated in FIG. **5**, may be comprised of a single paint injector. Such a machine may be employed to create both monochromatic and multiple color prints. For example, full color prints may be generated by printing each process color individually with a single injector. Accordingly, the injector could print the full image for a particular color separation (e.g. cyan). The injector would then, preferably, be cleaned and filled with another color (e.g. black). The processing device would be instructed as to which color is present in the injector, and the full image for that color separation would be printed. The process would be repeated for each of the other necessary or desired colors (e.g., white, magenta, and yellow) until the image is complete. Such a single injector device would be less expensive to manufacture as requiring fewer injectors to manufacture and would produce the same or comparable quality of prints.

In general, the invention comprises digitally controlling the immersion of an extracting device into paint and the advancement of the once immersed and now coated extracting device in front of a stream of air to remove the paint from the extracting device and deposit it onto a print medium. It is noted that while references are made to paint in the specification and claims, the term is intended to encompass inks, dyes, and any other liquid pigmented material that can be deposited on a surface for printing or painting purposes. Moreover, references to the term "wire" in the specification and claims is intended to encompass a cord, strand, thread, string, ribbon, filament, cable, line, band, belt, strap, or any other elongated segment of material whether in a loop or not and whether in a flexible, resilient, stretchable, or more rigid form. In addition, it is to be understood that the above-described embodiments are only illustrative of the application of the principles of the present invention. Numerous modifications and alternatives may be devised by those skilled in the art, including combinations of the various embodiments, without departing from the spirit and scope of the present invention. The appended claims are intended to cover such modifications, alternative arrangements, and combinations.

What is claimed is:

1. An apparatus for depositing a metered amount of a liquified pigmented material on a surface, comprising:

an electronically controllable drive mechanism;

a structure associated with said drive mechanism and movable thereby;

a liquified pigmented material supply in communication with said structure for depositing liquified pigmented material on at least a portion of said structure; and

at least one fluid nozzle having at least one nozzle orifice positioned and oriented for directing at least one jet of fluid toward at least a portion of said structure to remove an amount of liquified pigmented material from said structure and direct said amount toward a surface

whereby movement of said structure relative to said at least one fluid nozzle substantially controls the amount of liquified pigmented material removed from said structure.

2. The apparatus of claim **1**, wherein said structure comprises a wire.

3. The apparatus of claim **2**, wherein said wire is of a finite length.

4. The apparatus of claim **3**, wherein said drive mechanism comprises a wheel having a first circumferential groove and a second circumferential groove therein, said wire being at least partially disposed in said first circumferential groove passing in front of said at least one nozzle orifice and being at least partially disposed in said second circumferential groove.

5. The apparatus of claim **2**, wherein said at least one nozzle orifice comprises two nozzle orifices.

6. The apparatus of claim **5**, wherein said two nozzle orifices are substantially aligned with said wire for directing a jet of fluid at two locations on said wire.

7. The apparatus of claim **2**, further including a biasing device associated with said wire to maintain tension in said wire.

8. The apparatus of claim **7**, wherein said biasing device comprises a biased guide secured relative to said drive mechanism, said wire being disposed about at least a portion of said guide.

9. The apparatus of claim **2**, further including a mechanical metering device in contact with said wire for removing an amount of liquified pigmented material from said wire before said wire passes in front of said at least one orifice.

10. The apparatus of claim **9**, wherein said mechanical metering device comprises a pair of plates sandwiching said wire thereinbetween.

11. The apparatus of claim **10**, wherein said pair of plates includes first ends and second ends, said wire being sandwiched at two separate locations by said pair of plates.

12. The apparatus of claim 2, further including a wiping device in contact with said wire for removing liquified pigmented material from said wire before said wire is rewound onto said wheel.

13. The apparatus of claim 1, wherein said at least one nozzle orifice comprises an elongated slit.

14. The apparatus of claim 1, wherein said at least one nozzle orifice comprises a cross-shaped orifice.

15. The apparatus of claim 1, further including a reservoir containing liquified pigmented material, said structure at least partially disposed within said liquified pigmented material.

16. The apparatus of claim 15, further including a guide disposed in said reservoir for guiding said structure through said reservoir.

17. The apparatus of claim 16, wherein said guide is rotatable by said structure and includes at least one mixing device associated therewith.

18. The apparatus of claim 1, wherein said drive mechanism comprises a stepper motor.

19. An apparatus for depositing a liquified pigmented material on a surface to be painted, comprising:

means for providing a fluid jet;

means for advancing a liquified pigmented material disposed on at least a portion thereof relative to said fluid jet means, said fluid jet means oriented for removing liquified pigmented material from said advancing means and for directing said liquified pigmented material onto a surface to be painted;

means for controlling said advancing means and thus controlling the quantity of liquified pigmented material advanced relative to said fluid jet means.

20. The apparatus of claim 19, wherein said advancing means is comprised of at least one of an endless cable, an endless wire, a length of cable, a length of wire, a ribbon, an elongate rod, and a band.

21. The apparatus of claim 19, wherein fluid said jet means is comprised of a nozzle defining at least two orifices therein.

22. The apparatus of claim 21, wherein said at least two orifices are aligned with said advancing means to direct at least two fluid jets toward at least two distinct points along said advancing means.

23. The apparatus of claim 19, further including at least one wiping means for wiping liquified pigmented material from said advancing means before a portion of said advancing means carrying said liquified pigmented material across a path of said fluid jet means.

24. The apparatus of claim 23, wherein said wiping means is configured to also wipe said advancing means at at least two locations thereof.

25. The apparatus of claim 19, wherein said advancing means comprises a wire and further including a biasing means for maintaining tension in said wire.

26. A nozzle for directing a jet of fluid at an advanceable structure of a paint injector having a quantity of liquified pigmented material disposed thereon, comprising:

a nozzle body;

at least two orifices defined in said nozzle body, said at least two orifices oriented for directing at least two fluid jets toward at least two discrete points along a length of the advanceable structure to remove an amount of liquified pigmented material from the advanceable structure and direct said amount toward a surface to be painted.

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